

Table 1
The Chemours Company - Washington Works
PTFE Scrubber Emissions
Parkersburg, West Virginia

Run Identification	Run 1	Run 2	Run 3	Average	Run 1	Run 2	Run 3	Average
Run Date	24Aug18	24Aug18	24Aug18		24Aug18	24Aug18	24Aug18	
Start/Stop Time	0922-1022	1120-1220	1330-1430		0922-1025	1120-1220	1330-1430	
<u>Source ID</u>								
<u>Exhaust Gas Conditions</u>								
Temperature (deg. F)	245	250	245	247	115	115	116	115
Moisture (volume %)	4.1	4.0	4.2	4.1	7.3	7.9	7.6	7.6
Oxygen (dry volume %)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Carbon Dioxide (dry volume %)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
<u>Collected Sample Volume</u>								
dscf	51.694	51.879	50.097	51.223	46.820	43.995	45.061	45.292
<u>Volumetric Flow Rate</u>								
acf m	30,394	30,733	30,096	30,408	30,765	29,078	29,993	29,945
dscfm	22,127	22,194	21,882	22,068	26,441	24,850	25,694	25,662
<u>C3 Dimer Acid Emissions</u>								
mg	74.35	62.11	90.67	75.71	0.10	0.13	0.12	0.12
mg/dscm	5.08E+01	4.23E+01	6.39E+01	5.23E+01	7.37E-02	1.06E-01	9.42E-02	9.12E-02
lb/hr	4.21E+00	3.51E+00	5.24E+00	4.32E+00	7.30E-03	9.82E-03	9.07E-03	8.73E-03
<u>Removal Efficiency</u>								
percent	99.8	99.7	99.8	99.8				
<u>PFOA Emissions</u>								
mg	0.00733	0.00781	0.00939	0.00818	0.000414	0.000435	0.000406	0.000418
mg/dscm	5.01E-03	5.32E-03	6.62E-03	5.65E-03	3.12E-04	3.49E-04	3.18E-04	3.27E-04
lb/hr	4.15E-04	4.42E-04	5.43E-04	4.67E-04	3.09E-05	3.25E-05	3.06E-05	3.14E-05
<u>Removal Efficiency</u>								
percent	92.5	92.6	94.4	93.3				



Example Calculations
The Chemours Company - Washington Works
PTFE Scrubber Inlet
Parkersburg, West Virginia

Note: Values are shown for example purposes only.

V_{m,a} = Dry gas volume at actual conditions (acf)

Initial gas meter volume:	80.886
Final gas meter volume:	133.455
Difference:	52.569

V_{m,std} = Volume of dry gas at standard conditions (dscf)

$$\begin{aligned}
 &= 17.647 \times V_{m,a} \times \text{Gamma} * [\text{Pbar} + (\Delta H / 13.6)] / T_m(R) \\
 &= 17.647 \times 0.000 \times 0.978 \times (30.20 + [(-1.680 / 13.6)]) / 533 \\
 &= 51.694
 \end{aligned}$$

V_{l,c} = Volume of water collected in impingers and silica gel (ml)

impinger catch (mls):	34
silica gel (g)	12.6
total:	46.6

V_{w,std} = Volume of water vapor in gas at standard conditions (cu.ft.)

$$\begin{aligned}
 &= (0.04707) \times (V_{l,c}) \\
 &= 0.04707 \times 46.6 \\
 &= 2.193
 \end{aligned}$$

B_{wo} = Proportion by volume of water vapor in gas stream

$$\begin{aligned}
 &= V_{w,std} / (V_{w,std} + V_{m,std}) \\
 &= 2.19 / (2.19 + 51.694) \\
 &= 0.041
 \end{aligned}$$

P_s = Stack gas static pressure (in. Hg)

$$\begin{aligned}
 &= St / 13.6 \\
 &= 1.70 / 13.6 \\
 &= 0.125
 \end{aligned}$$

P_a = Absolute stack gas pressure (in. Hg)

$$\begin{aligned}
 &= P_s + P_{bar} \\
 &= 0.125 + 30.20 \\
 &= 30.33
 \end{aligned}$$

MFD = Dry mole fraction of stack gas

$$\begin{aligned}
 &= 1 - B_{wo} \\
 &= 1 - 0.041 \\
 &= 0.959
 \end{aligned}$$


Example Calculations
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PTFE Scrubber Inlet
Parkersburg, West Virginia

Note: Values are shown for example purposes only.

Md =	Dry molecular weight of stack gas (lb/lb-mol)
=	$(0.32 \times \%O_2) + (0.44 \times \%CO_2) + (0.28 \times \%N_2)$
=	$(0.32 \times 20.00) + (0.44 \times 0.10) + (0.28 \times 79.90)$
=	28.82
Mw =	Wet molecular weight of stack gas (lb/lb-mol)
=	$(Md) \times (MFD) + (0.18) \times (Bwo \times 100)$
=	$28.82 \times 0.959 + 0.18 \times 4.0705$
=	28.38
Vs,avg =	Average stack gas velocity (fps)
=	$K_p \times (C_p) \times (\sqrt{\Delta P} \times \sqrt{(T_s + 460^\circ R) / M_w \times P_a})$
=	$85.48 \times 0.84 \times 1.10 \times \sqrt{0.82}$
=	71.7
A	Cross sectional areas of stack (sq. ft)
=	$\pi / 4 \times d^2$
=	$3.14159 / 4 \times 3.00^2$
=	7.07
Qa	Volumetric flow rate at actual conditions (acf m)
=	$(60) \text{sec/min} \times (A) \times (Vs, \text{ avg})$
=	$60 \times 7.0686 \times 71.66$
=	30,391
Qstd	Volumetric flow rate at standard conditions (scfm)
=	$Qa \times (528 / (T_s, \text{ avg} + 460)) \times P_a / 29.92$
=	$30,391 \times (528 / 705) \times 1.014$
=	23,064
Qstd,dry	Volumetric flow rate at dry standard conditions per minute(dscfm)
=	$Qstd \times (1 - Bwo)$
=	$23,064 \times 0.9593$
=	22,125
mg/dscm	HFPO-DA concentration
=	$(mg/dscf) \times (35.314 \text{ cubic feet/cubic meter})$
=	$(74.347 / 51.694) \times 35.314$
=	50.7891
lb/hr	HFPO-DA Mass Emission Rate
=	$mg/1000 / [(453.59 \text{ g/lb}) / (dscf)] \times dscfm \times 60 \text{ min/hr}$
=	$(74.3469 / 1,000 / (453.59 / 51.694)) \times 22,127 \times 60$
=	4.21E+00



Table 2
The Chemours Company - Washington Works
PFA Scrubber Emissions
Parkersburg, West Virginia

Run Identification	Run 1	Run 2	Run 3	Average	Run 1	Run 2	Run 3	Average
Run Date	06Nov18	06Nov18	06Nov18		06Nov18	06Nov18	06Nov18	
Start/Stop Time	1315-1415	1510-1610	1717-1817		1315-1415	1510-1610	1717-1817	
<u>Source ID</u>								
<u>Exhaust Gas Conditions</u>								
Temperature (deg. F)	279	277	282	279	68	69	63	67
Moisture (volume %)	49.6	50.8	47.6	49.3	1.3	1.7	2.4	1.8
Oxygen (dry volume %)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Carbon Dioxide (dry volume %)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
<u>Collected Sample Volume</u>								
dscf	42.677	41.569	41.492	41.913	30.492	31.139	33.548	31.726
<u>Volumetric Flow Rate</u>								
acf m	1,031	1,003	990	1,008	449	427	488	455
dscfm	372	354	370	366	441	417	479	446
<u>C3 Dimer Acid Emissions</u>								
mg	315.028	471.959	281.478	356.155	2.3063	1.9683	2.7993	2.3580
mg/dscm	2.61E+02	4.01E+02	2.40E+02	3.00E+02	2.67E+00	2.23E+00	2.95E+00	2.62E+00
lb/hr	3.64E-01	5.32E-01	3.32E-01	4.09E-01	4.42E-03	3.49E-03	5.29E-03	4.40E-03
<u>Removal Efficiency</u>								
percent	98.8	99.3	98.4	98.9				
<u>PFOA Emissions</u>								
mg	0.59626	0.59157	0.57470	0.58751	0.00381	0.00362	0.00416	0.00386
mg/dscm	4.93E-01	5.03E-01	4.89E-01	4.95E-01	4.41E-03	4.11E-03	4.38E-03	4.30E-03
lb/hr	6.88E-04	6.67E-04	6.78E-04	6.78E-04	7.30E-06	6.42E-06	7.86E-06	7.19E-06
<u>Removal Efficiency</u>								
percent	98.9	99.0	98.8	98.9				



Example Calculations
The Chemours Company - Washington Works
PFA Scrubber Inlet
Parkersburg, West Virginia

Note: Values are shown for example purposes only.

V_{m,a} = Dry gas volume at actual conditions (acf)

Initial gas meter volume:	239.462
Final gas meter volume:	282.676
Difference:	43.214

V_{m,std} = Volume of dry gas at standard conditions (dscf)

$$\begin{aligned}
 &= 17.647 \times V_{m,a} \times \text{Gamma}^* [P_{\text{bar}} + (\Delta H / 13.6)] / T_m(R) \\
 &= 17.647 \times 0.000 \times 0.987 \times (29.79 + [(1.630 / 13.6)] / 527) \\
 &= 42.677
 \end{aligned}$$

V_{l,c} = Volume of water collected in impingers and silica gel (ml)

impinger catch (mls):	882
silica gel (g)	11.0
total:	893.4

V_{w,std} = Volume of water vapor in gas at standard conditions (cu.ft.)

$$\begin{aligned}
 &= (0.04707) \times (V_{l,c}) \\
 &= 0.04707 \times 893.4 \\
 &= 42.052
 \end{aligned}$$

B_{wo} = Proportion by volume of water vapor in gas stream

$$\begin{aligned}
 &= V_{w,std} / (V_{w,std} + V_{m,std}) \\
 &= 42.05 / (42.05 + 42.677) \\
 &= 0.496
 \end{aligned}$$

P_s = Stack gas static pressure (in. Hg)

$$\begin{aligned}
 &= St / 13.6 \\
 &= 2.90 / 13.6 \\
 &= 0.213
 \end{aligned}$$

P_a = Absolute stack gas pressure (in. Hg)

$$\begin{aligned}
 &= P_s + P_{\text{bar}} \\
 &= 0.213 + 29.79 \\
 &= 30.00
 \end{aligned}$$

MFD = Dry mole fraction of stack gas

$$\begin{aligned}
 &= 1 - B_{wo} \\
 &= 1 - 0.496 \\
 &= 0.504
 \end{aligned}$$



Example Calculations
The Chemours Company - Washington Works
PFA Scrubber Inlet
Parkersburg, West Virginia

Note: Values are shown for example purposes only.

Md =	Dry molecular weight of stack gas (lb/lb-mol)
	= $(0.32 \times \%O_2) + (0.44 \times \%CO_2) + (0.28 \times \%N_2)$
	= $(0.32 \times 20.00) + (0.44 \times 0.10) + (0.28 \times 79.90)$
	= 28.82
Mw =	Wet molecular weight of stack gas (lb/lb-mol)
	= $(Md) \times (MFD) + (0.18) \times (Bwo \times 100)$
	= $28.82 \times 0.504 + 0.18 \times 49.631$
	= 23.45
Vs,avg =	Average stack gas velocity (fps)
	= $K_p \times (C_p) \times (\sqrt{\Delta P}) \times \sqrt{((T_s + 460^\circ R) / M_w \times P_a)}$
	= $85.48 \times 0.84 \times 0.67 \times \sqrt{1.05}$
	= 49.2
A	Cross sectional areas of stack (sq. ft)
	= $\pi / 4 \times d^2$
	= $3.14159 / 4 \times 0.67^2$
	= 0.35
Qa	Volumetric flow rate at actual conditions (acf m)
	= $(60) \text{sec/min} \times (A) \times (V_s, \text{avg})$
	= $60 \times 0.3491 \times 49.22$
	= 1,031
Qstd	Volumetric flow rate at standard conditions (scfm)
	= $Q_a \times (528 / T_s, \text{avg} + 460) \times P_a / 29.92$
	= $1,031 \times (528 / 739) \times 1.003$
	= 739
Qstd,dry	Volumetric flow rate at dry standard conditions per minute(dscfm)
	= $Q_{std} \times (1 - Bwo)$
	= 739×0.5037
	= 372
mg/dscm	HFPO-DA concentration
	= $(\text{mg/dscf}) \times (35.314 \text{ cubic feet/cubic meter})$
	= $(315.028 / 42.677) \times 35.314$
	= 260.677
lb/hr	HFPO-DA Mass Emission Rate
	= $\text{mg/1000} / [(453.59 \text{ g/lb}) / (\text{dscf})] \times \text{dscfm} \times 60 \text{ min/hr}$
	= $(315.028 / 1,000 / (453.59 / 42.677)) \times 372.29 \times 60$
	= 3.64E-01



Table 3
The Chemours Company - Washington Works
FEP Scrubber Emissions
Parkersburg, West Virginia

Run Identification	Run 1	Run 2	Run 3	Average	Run 1	Run 2	Run 3	Average	Run 1	Run 2	Run 3	Average
Run Date	07Nov18	07Nov18	07Nov18		07Nov18	07Nov18	07Nov18		07Nov18	07Nov18	07Nov18	
Start/Stop Time	1055-1155	1325-1425	1540-1640		1055-1155	1325-1425	1540-1640		1055-1155	1325-1425	1540-1640	
<u>Source ID</u>												
Line 2 Scrubber Inlet												
<u>Exhaust Gas Conditions</u>												
Temperature (deg. F)	228	211	218	219	194	190	193	192	61	59	61	60
Moisture (volume %)	21.5	21.9	22.8	22.1	21.6	17.9	22.6	20.7	1.5	1.4	1.1	1.3
Oxygen (dry volume %)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Carbon Dioxide (dry volume %)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
<u>Collected Sample Volume</u>												
dscf	44.804	46.419	46.795	46.006	41.993	39.440	38.248	39.894	57.283	55.145	56.019	56.149
<u>Volumetric Flow Rate</u>												
acf m	463	471	480	471	801	730	722	751	1,735	1,698	1,715	1,716
dscfm	279	289	288	285	506	487	451	481	1,745	1,716	1,730	1,730
<u>C3 Dimer Acid Emissions</u>												
mg	105.895	92.954	98.491	99.114	159.133	96.958	121.853	125.981	0.05337	0.01192	0.02336	0.030
mg/dscm	8.35E+01	7.07E+01	7.43E+01	7.62E+01	1.34E+02	8.68E+01	1.13E+02	1.11E+02	3.29E-02	7.63E-03	1.47E-02	1.84E-02
lb/hr	8.72E-02	7.65E-02	8.01E-02	8.13E-02	2.54E-01	1.58E-01	1.90E-01	2.01E-01	2.15E-04	4.91E-05	9.54E-05	1.20E-04
<u>Removal Efficiency</u>												
percent	99.8	99.9	99.9	99.9								
<u>PFOA Emissions</u>												
mg	0.11331	0.11810	0.12854	0.11999	0.14263	0.10118	0.12438	0.12273	0.00088	0.00065	0.00077	0.00077
mg/dscm	8.93E-02	8.98E-02	9.70E-02	9.21E-02	1.20E-01	9.06E-02	1.15E-01	1.08E-01	5.41E-04	4.14E-04	4.87E-04	4.81E-04
lb/hr	9.33E-05	9.72E-05	1.05E-04	9.83E-05	2.27E-04	1.65E-04	1.94E-04	1.95E-04	3.53E-06	2.66E-06	3.16E-06	3.12E-06
<u>Removal Efficiency</u>												
percent	96.2	97.3	97.0	96.8								



Example Calculations
The Chemours Company - Washington Works
FEP Line 2 Scrubber Inlet
Parkersburg, West Virginia

Note: Values are shown for example purposes only.

V_{m,a} = **Dry gas volume at actual conditions (acf)**

Initial gas meter volume:	528.478
Final gas meter volume:	573.300
Difference:	44.822

V_{m,std} = **Volume of dry gas at standard conditions (dscf)**

$$\begin{aligned} &= 17.647 \times V_{m,a} \times \text{Gamma} * [P_{\text{bar}} + (\Delta H / 13.6)] / T_m(R) \\ &= 17.647 \times 0.000 \times 0.987 \times (30.09 + [(1.710 / 13.6)] / 527) \\ &= 44.804 \end{aligned}$$

V_{l,c} = **Volume of water collected in impingers and silica gel (ml)**

impinger catch (mls):	250
silica gel (g)	10.4
total:	260.2

V_{w,std} = **Volume of water vapor in gas at standard conditions (cu.ft.)**

$$\begin{aligned} &= (0.04707) \times (V_{l,c}) \\ &= 0.04707 \times 260.2 \\ &= 12.248 \end{aligned}$$

B_{wo} = **Proportion by volume of water vapor in gas stream**

$$\begin{aligned} &= V_{w,std} / (V_{w,std} + V_{m,std}) \\ &= 12.25 / (12.25 + 44.804) \\ &= 0.215 \end{aligned}$$

P_s = **Stack gas static pressure (in. Hg)**

$$\begin{aligned} &= St / 13.6 \\ &= -3.00 / 13.6 \\ &= -0.221 \end{aligned}$$

P_a = **Absolute stack gas pressure (in. Hg)**

$$\begin{aligned} &= P_s + P_{\text{bar}} \\ &= -0.221 + 30.09 \\ &= 29.87 \end{aligned}$$

MFD = **Dry mole fraction of stack gas**

$$\begin{aligned} &= 1 - B_{wo} \\ &= 1 - 0.215 \\ &= 0.785 \end{aligned}$$



Example Calculations
The Chemours Company - Washington Works
FEP Line 2 Scrubber Inlet
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Note: Values are shown for example purposes only.

Md = Dry molecular weight of stack gas (lb/lb-mol)

$$\begin{aligned} &= (0.32 \times \%O_2) + (0.44 \times \%CO_2) + (0.28 \times \%N_2) \\ &= (0.32 \times 20.00) + (0.44 \times 0.10) + (0.28 \times 79.90) \\ &= 28.82 \end{aligned}$$

Mw = Wet molecular weight of stack gas (lb/lb-mol)

$$\begin{aligned} &= (Md) \times (MFD) + (0.18) \times (Bwo * 100) \\ &= 28.82 \times 0.785 + 0.18 \times 21.468 \\ &= 26.49 \end{aligned}$$

Vs,avg = Average stack gas velocity (fps)

$$\begin{aligned} &= Kp \times (Cp) \times (\sqrt{T_s + 460} / Mw * Pa) \\ &= 85.48 \times 0.84 \times 0.54 \times \sqrt{0.87} \\ &= 36.2 \end{aligned}$$

A = Cross sectional areas of stack (sq. ft)

$$\begin{aligned} &= \pi / 4 * d^2 \\ &= 3.14159 / 4 \times 0.52^2 \\ &= 0.21 \end{aligned}$$

Qa = Volumetric flow rate at actual conditions (acf m)

$$\begin{aligned} &= (60)sec/min(A)(Vs, avg) \\ &= 60 \times 0.2131 \times 36.23 \\ &= 463 \end{aligned}$$

Qstd = Volumetric flow rate at standard conditions (scfm)

$$\begin{aligned} &= Qa \times (528/Ts,avg + 460) \times Pa/29.92 \\ &= 463 \times (528 / 688) \times 0.998 \\ &= 355 \end{aligned}$$

Qstd,dry = Volumetric flow rate at dry standard conditions per minute(dscfm)

$$\begin{aligned} &= Qstd \times (1-Bwo) \\ &= 355 \times 0.7853 \\ &= 279 \end{aligned}$$

mg/dscm = HFPO-DA concentration

$$\begin{aligned} &= (mg/dscf) \times (35.314 \text{ cubic feet/cubic meter}) \\ &= (105.895 / 44.804) \times 35.314 \\ &= 83.465 \end{aligned}$$

lb/hr = HFPO-DA Mass Emission Rate

$$\begin{aligned} &= mg/1000 / [(453.59 \text{ g/lb}) / (dscf)] \times dscfm \times 60 \text{ min/hr} \\ &= (105.895 / 1,000 / (453.59 / 44.804)) \times 278.77 \times 60 \\ &= 8.72E-02 \end{aligned}$$

